Part 1. Report Cover

Report Number: **F006**

Title: Performance Oriented Packaging Testing of a 16 inch
By 16 inch by 16 inch Grade V3c Fiberboard Box, with
1-Gallon, Rectangular Metal, Cans, (quantity of 4) –
Packing Group I (Surface Modes Only)

Responsible Individual: R. Craig Webb, Code 512, DSN 744-4142 or Commercial (360)396-4142

Performing Activity: Naval Undersea Warfare Center Division, Keyport
610 Dowell Street, Keyport, WA 98345-7610

Original Report Date: July 2001

Report Type: Final

Keyport Report Number: 01KPT03R

DTIC Distribution: N/A

Requesting Organization:

Defense Logistics Agency
Defense Distribution Center
ATTN: DDC-TO
2001 Mission Drive
New Cumberland, PA 17170-5000

Requesting Organization's Reference(s):

DDC memo of 06 Dec 00, Subj: Performance Oriented Tests to be Performed in 2001

Part 2. Data Sheet

A. Exterior Shipping Container

UN Type:	Fiberboard Box
UN Code:	4G
Specification Number(s):	ASTM D5118, Style RSC, ASTM D 4727, Type CF, Class WR, Varity SW, Grade V3c NSN 8115-00-190-5002
Container Supplier:	Lynchburg Sheltered Industries, Lynchburg VA,
Date of Manufacture:	N/A
Material:	Corrugated Fiberboard

Container Dimensions: 16 inches by 16 inches by 16 inches

Closure (Type/Method):	ASTM D1974, Sealing Method B (7-Strip Method), Use 2-inch A-A-1830 Clear Tape on closure.
Closure Spec. Numbers:	A-A-1830 Clear Tape, Clear Tape, 2-inch
Reinforcement (Method):	Use 1-inch Filament Reinforced Tape IAW A-A-1687, 2 Girthwise Bands (3-inches from each end) encircling top, bottom and sides, reinforcement method 2B and 3 horizontal bands (3-inches from the top and bottom and one centered) encircling the ends and sides.
Reinforcement Spec. #s:	A-A-1687 Fiber Reinforced Tape, 1-inch
Absorbent Material:	Vermiculite, Fine Grain, Grace Zonolite Construction Products, NSN 8135-01-324-2664

(Note: Additional testing was done with Absorbent GP and A-900. The cushioning effect was similar to vermiculite and testing results were the same. However, scientific study results of the absorbent qualities of these two material types were not available to the testing lab.)

B. Inner Packaging of Combination Packaging:

Type:	Rectangular Metal Can
NSN:	N/A
Manufacturer/Distributor:	Freund Can Company
Date of Manufacture:	N/A
Manufacturer's Number:	N/A
Capacity:	1-Gallon (128 ounces)
Dimensions:	4 1/8 in. wide x 6 5/8 in. long x 10 1/4 in. height
Closure (Type/Method):	Metal Cap
Secondary Closure (Type/Method):	Fiber Reinforce Tape

C. Actual Product: Not Used

D. Test Product: Used (water)
UN Packaging Group: I
Physical State: Liquid
Amount per Container: 4 (36.4 lbs. total, 9.1 lbs. each)
Test Weight: 63.1 lbs. (28.8 kg)
Density/Specific Gravity: 1.0
Drop Height: 71 in. (1.8 m)
Stacking Weight/Force: 500 lbs. (222 kg)
Additional Description:

1. Line the box with 4 Mil Polyethylene bag. Minimum size – 35 inches wide by 39 inches high. Actual sized used – 36 in. wide x 48 in. high.
2. Place 3 inches of vermiculite in the bottom of the box.
3. Place 4 cans (2 rows of 2 cans) on the vermiculite centered in the box.
4. Surround the cans with vermiculite and cover to a depth of 3-inches, pack tightly.
5. Twist bag and tape closed. (Closure IAW MIL-D-6054F)

Part 3. Test Applicability:

A. Based on the drop height, computed stacking weight, and internal pressure maintenance, this test report is applicable for all surface modes of transportation including international and domestic (road, rail, and water) when the liquid hazardous substance intended for containment by the tested packaging is as described in this report. Transportation by commercial (cargo and passenger) or military air is not permitted. The appropriate packaging paragraph for the lading applies.

B. Pass/fail conclusions were based on the particular fiberboard box specimens, test loads, and the limited quantities submitted for test. Extrapolation to other materials, other manufacturers, other applications, different inner packagings, container sizes, or lesser inner quantities is the responsibility of the packaging design agency or applicable higher headquarters. Extrapolation of test results based on less than the minimum recommended number of test specimens is also the responsibility of the packaging design agency or applicable higher headquarters.

C. Reference to specification materials has been made based either on the information provided by the requester, the manufacturer, or the markings printed on, attached to, or embossed on the packaging.

D. Testing was performed per Title 49 Code of Federal Regulations except as noted in this report.

E. Performance testing was undertaken and completed at the request of an agency responsible for the shipment of dangerous goods. The successful completion of required performance tests does not, by itself, authorize the marking and transportation of the dangerous goods. Applicable modal regulations should be consulted concerning the relationship of performance testing completed and the dangerous goods.

F. Required performance tests are intended to evaluate the performance of the packaging components. The criteria used to evaluate packaging performance is whether the contents of the packaging are retained within the outer packaging, should damage to the outer packaging occur, and secondly, if any inner packaging of hazardous materials leaks, ruptures, or is damaged so as to affect transportation safety. The successful completion of the required tests does not ensure the undamaged delivery or survivability of the actual commodity/item.

G. Before a configuration can be certified by the person(s) authorizing shipment, the appropriate packaging for the particular hazardous lading and mode of transportation must be determined, and the item(s) must be prepared for shipment per applicable regulations. The chosen configuration must have been performance tested in accordance with the size, the shape,

and the weight constraints posed by configuration to be certified. The testing reported herein should not be construed as blanket certification of any configuration that simply uses the performance tested package. Packaging paragraphs apply.

Part 4. Tests Required:

Packing Group I (greater danger) testing was requested for the above stated configuration. This configuration is intended to be applicable to a large assortment of liquid products contained in metal cans. These tests are designed to simulate the static loading, shock, and vibration a package (configuration) may encounter when being shipped worldwide by truck, rail, or ocean going transport. The order of testing was static loading, vibration, and drop, followed by water resistance testing.

A. Stacking Test:

Three containers are required, one test per container. Compression by a top load is calculated to simulate a stack of height of 3 meters, maintained for 24 hours, followed by testing the container stability by placing two loaded containers on top of the tested container for at least 1 hour.

B. Vibration Test:

Three sample packagings must be filled and closed as for shipment. The samples must be placed on a vibrating platform designed to simulate actual vibrations encountered during transportation. The packages should be constrained horizontally to prevent them from falling off the platform, but must be left free to move vertically, and bounce and rotate.

C. Drop Test:

Five drops, requiring 5 sample containers. First drop (using the first sample), the package must strike the target flat on the bottom. Second drop (using the second sample), the package must strike the target flat on the top. Third drop (using third sample), flat on the long side. Fourth drop (using fourth sample), flat on the short side. Fifth drop (using the fifth sample) on a corner. The drop height shall be appropriated or the packaging group of the commodity. The container shall strike the target, which shall be a rigid, non-resilient, flat, horizontal surface. For other than flat drops, the center of gravity shall be vertically over the point of impact.

D. Water Resistance Test (Cobb Method)

Many factors may affect water absorption by corrugated fiberboard. Among these factors are abrasion, wear, flexure, improper storage, and age. These can greatly decrease the

ability of the fiberboard to resist water absorption and result in higher than tested results. In addition, some fiberboard products are only treated on one side of the material, making the box construction method of increased importance. Usually, the water-resistant side is the smooth side. The shipper must take appropriate steps to ensure that the box is correctly constructed with the water-resistant side on the outside.

Part 5. Applicable Packing Group Test Requirements:

A. Stacking Test:

Apply the calculated static weight using a constant load evenly over the entire container.

$$M = \frac{m\,(3000-h)}{h}$$

where: m = container's gross mass (as shipped) in kilograms
h = container's height in millimeters
M = constant load mass in kilograms

or:

$$W = \frac{w\,(118-h)}{h}$$

where: w = container's gross weight (as shipped) in pounds
h = container's height in inches
W = constant load weight in pounds

Note: This test assumes similar weight containers stacked on top of the test sample. This may or many not be a valid assumption. This calculation also only provides a minimum weight. Consideration should be given to what will actually be experienced in the transportation cycle.

B. Vibration:

The test shall be performed for 1 hour at a frequency that causes the package to be raised from the vibrating platform to such a degree that a piece of material approximately 1/16 inch (0.2 cm) thick can be passed between the bottom of the package and the platform. The vibrating platform shall have a vertical double-amplitude (peak-to-peak) displacement of one-inch (2.54 cm). Test shall be performed in accordance to 49 CFR 173 Subpart B, Appendix C and 49 CFR 178.

C. Drop Test:

Solids and liquids, if the test is performed with the actual contents to be carried, or with another substance having essentially the same characteristics, or for liquids if the test is performed with water and the intended contents has a density of less than 1.2 g/cm^3 (specific gravity less than 1.2) the drop height shall be:

Packing Group	Drop Height
I	1.8 m (70.9 inches)
II	1.2 m (47.2 inches)
III	0.8 m (31.5 inches)

Where the test sample doesn't contain the intended contents and its specific gravity is greater than 1.2, then obtain the required drop height in meters by calculating the following with product density (d):

Packing Group	Drop Height
I	(d) x 1.5 m or (d x 59.1 inches)
II	(d) x 1.0 m or (d x 39.4 inches)
III	(d) x .67 m or (d x 26.4 inches)

Round the drop height up to the first decimal.

D. Water Resistance Test (Cobb Method)

The Cobb Method of water resistance testing is spelled out in detail in the Technical Association of Pulp and Paper Industry (TAPPI) document T441. Test procedure, conditioning requirements, time of duration, test apparatus and equipment are all specified. These requirements can also be found in ISO 535 and ASTM 3285.

Part 6. Criteria for Passing Tests:

A. Stacking Test:

No test sample shall leak. Composite and combination containers shall not exhibit leakage of the filling substance from the inner receptacle or container. No test sample shall show any distortion liable to reduce its strength, cause stacking instability, or cause damage to internal container components likely to reduce transportation safety. The outer packaging must meet the stacking test requirements when empty in order to meet the variation 2 conditions.

B. Vibration Test:

Each packaging must be able to withstand the vibration test procedure without rupture or leakage. Immediately after testing each sample shall be turned on its side and observed for evidence of leakage. No test sample shall show any deterioration, which could adversely affect transportation safety, result in possible discharge of contents or reduce packaging strength.

C. Drop Test:

There must be no damage to the outer packaging likely to adversely affect safety during transport, and there is no leakage of the filling substance from the inner packaging.

D. Fiberboard Water Resistance Test (Cobb Method):

Strong, solid or double-faced corrugated fiberboard (single or multi-walled) must be used, appropriate for the capacity and the intended use of the box. The water resistant outer surface must not increase in mass greater than 155 grams per meter squared (0.0316 pounds per square foot) in accordance with International Standards Organization (ISO) 535 or Technical Association of the Pulp and Paper Industry (TAPPI) T441 or ASTM D3285. Three individual fiberboard specimens shall be exposed on the wire side and another three on the felt side.

Part 7. Test Results and Discussion:

A. Stacking Test: PASS

Three empty boxes were stacked with 500 lbs. and maintained in that condition for a period of 24 hours with no visible damage or adverse effects. Five hundred pounds exceeds the minimum calculated value of 390 pounds. The same three boxes were then packed as described in Part 2 and again stacked with 500 lbs. for a period of 24 hours with no visible damage or adverse effects.

B. Vibration Test: PASS

The three boxes packed as described above were subjected to the vibration test. Each was tested on a vibration table, which was set a 1-inch vertical double amplitude (peak-to-peak) displacement, at a frequency such that the fiberboard box was raised from the platform. The distance was measured using a 1/16-inch feeler gage. The frequency was set such that the feeler gage could be passed between the bottom of the package and the table surface. There was no damage or adverse effects in evidence to the fiberboard box or its contents.

C. Drop Test: PASS

One box, which was reused from both the stack and vibration tests, was dropped 71 inches (1.8 m) onto a two-inch thick steel impact plate. This box was subjected to five drops as follows; flat on the bottom, flat on the top, flat onto the long side, flat on the short side, and finally on a corner. There was minimal damage to the test loads. Except for minor denting of

the impacted area, no adverse results were noted.

The decision to use the same container (configuration) for all drops was based on the relatively minimal damage demonstrated during previous testing. Five drops per fiberboard box exceeds 49 CFR 178.603 requirements, as well as both UN and ASTM recommendations (i.e., one drop diagonally onto a chime, one drop on the next weakest part, repeated using six samples total). The use of one configuration for multiple tests and drops is DOD policy as stated in draft regulation DLAR 4145.41/AR 700-143/AFR 71-5/NAVSUPINST 4030.55/MCO 4030.40, Packaging of Hazardous Material, the use of which was directed by MMDOS Letter 94-1 (same title), and its use extended by agreement during the DOD Performance Oriented Packaging Working Group meeting, Richmond, VA, 19-21 Sep 95.

D. Fiberboard - water resistance test (Cobb Method) PASS

The Cobb Method Test for water absorptiveness was performed on specimens cut from the boxes used in the (empty) stack test.

Three Specimens were tested on the exterior side. Average 122.9 g/m^2
Values: 121.4 g/m^2 123.7 g/m^2 123.6 g/m^2

Three Specimens were tested on the interior side. Average 118.0 g/m^2
Values: 118.0 g/m^2 119.5 g/m^2 116.6 g/m^2

No specimens exceeded the 155 grams per square meter maximum limit.

Part 8. References:

A. Title 49 Code of Federal Regulations
B. International Air Transportation Association Dangerous Goods Regulations
C. ASTM D 4919, Specification for Testing of Hazardous Materials Packagings
D. ASTM D 999, Standard Method for Vibration Testing of Shipping Containers
E. DLAD 4145.41/AR 700-143/AFJI 24-201/NAVSUPINST 4030.55A/MCO 4030.40A, Packaging of Hazardous Materials
F. ISO 535/TAPPI T 441/ASTM 3285 – Determination of Water absorption of Paper and Board (Cobb Method)

Part 9. Distribution List:

Commander
DDC-TO
Attn: Linda McCarthy
2001 Mission Drive

New Cumberland PA 17017